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INTERIM REPORT
February 24, 1993

FOR

BIOVENTING FIELD INITIATIVE

AT

WESTOVER AIR FORCE BASE, MASSACHUSETTS

to

Captain Catherine M. Vogel
Department of the Air Force
AL/EQW
139 Barnes Drive
Tyndall AFB, Florida 32403-5319

by

BATTELLE
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Columbus, Ohio 43201-2693

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INTERIM REPORT

BIOVENTING FIELD INITIATIVE

WESTOVER AIR FORCE BASE, MASSACHUSETTS

1.0 INTRODUCTION

This report describes the activities conducted at Westover Air Force Base (AFB), Massachusetts, as part of the Bioventing Field Initiative for the U.S. Air Force Center for Environmental Excellence (AFCEE) and the Environics Directorate of the Air Force Armstrong Laboratory. This report summarizes the results from the first phase of the study at Westover AFB. First-phase activities include a soil gas survey, air permeability test, in situ respiration test, and installation of bioventing systems. The specific objectives of this Bioventing Field Initiative are described in the following section. The test site at the base is discussed individually, followed by a description of site activities at the background area.

1.1 Objectives

The purpose of this Bioventing Field Initiative is to measure the soil gas permeability and microbial activity at a contaminated site in order to evaluate the potential application of bioventing technology to remediate the site. The specific test objectives are stated below.

- A small-scale soil gas survey will be conducted to identify an appropriate location for installation of the bioventing system. Soil gas from the candidate site should exhibit high total petroleum hydrocarbon (TPH) concentrations, relatively low oxygen concentrations, and relatively high carbon dioxide concentrations. An uncontaminated background location also will be identified.

- The soil gas permeability of the soil and the air vent (well) radius of influence will be determined. To measure these parameters, air will be withdrawn or injected for approximately 8 hours at vent wells located in contaminated soils. Pressure changes will be monitored in an array of monitoring points.

- Immediately following the soil gas permeability test, an in situ respiration test will be conducted. Air will be injected into selected monitoring points to

aerate the soils. The in situ oxygen utilization and carbon dioxide production rates will be measured.

- The data from the soil gas permeability and in situ respiration tests will be used to determine an air injection/withdrawal rate for the bioventing test. A blower will be selected, installed, and operated for 6 to 12 months, and periodic measurements of the soil gas composition will be made to evaluate the long-term effectiveness of bioventing.

1.2 Site Description

Westover AFB is located in the town of Chicopee north of Springfield, Massachusetts. A schematic diagram of the base is shown in Figure 1. The dashed line on the map represents the direction from the main gate to the test site. The hangar/apron area must be crossed to reach the test site and an escort is required at this point. The site chosen for the bioventing test initiative is located adjacent to Building 7705 and Building 7701 in the pumphouse area (Figure 2). Site investigation activities in the area have indicated soils and groundwater are contaminated with JP-4 jet fuel, with soil TPH concentrations above 2,000 ppm. The sources of contamination are the historic activities in the fuel hydrant area and a JP-4 fuel spill during Desert Shield activities.

Groundwater generally is encountered at 12 to 15 feet below ground surface. Soils at the site consist of fine sand to approximately 5 feet below ground surface, fine to medium sand to 15 feet below ground surface, and fine sand with trace silt to 20 feet below ground surface. A detailed description is provided in the Test Plan in Appendix A.

2.0 CHRONOLOGY OF EVENTS AND SITE ACTIVITIES

2.1 Groundwater Measurements

One groundwater monitoring well (MW-10) was measured at Buildings 7701 and 7705 Site. Groundwater level was recorded at 15 feet during October. Product was measured at 0.3 foot.

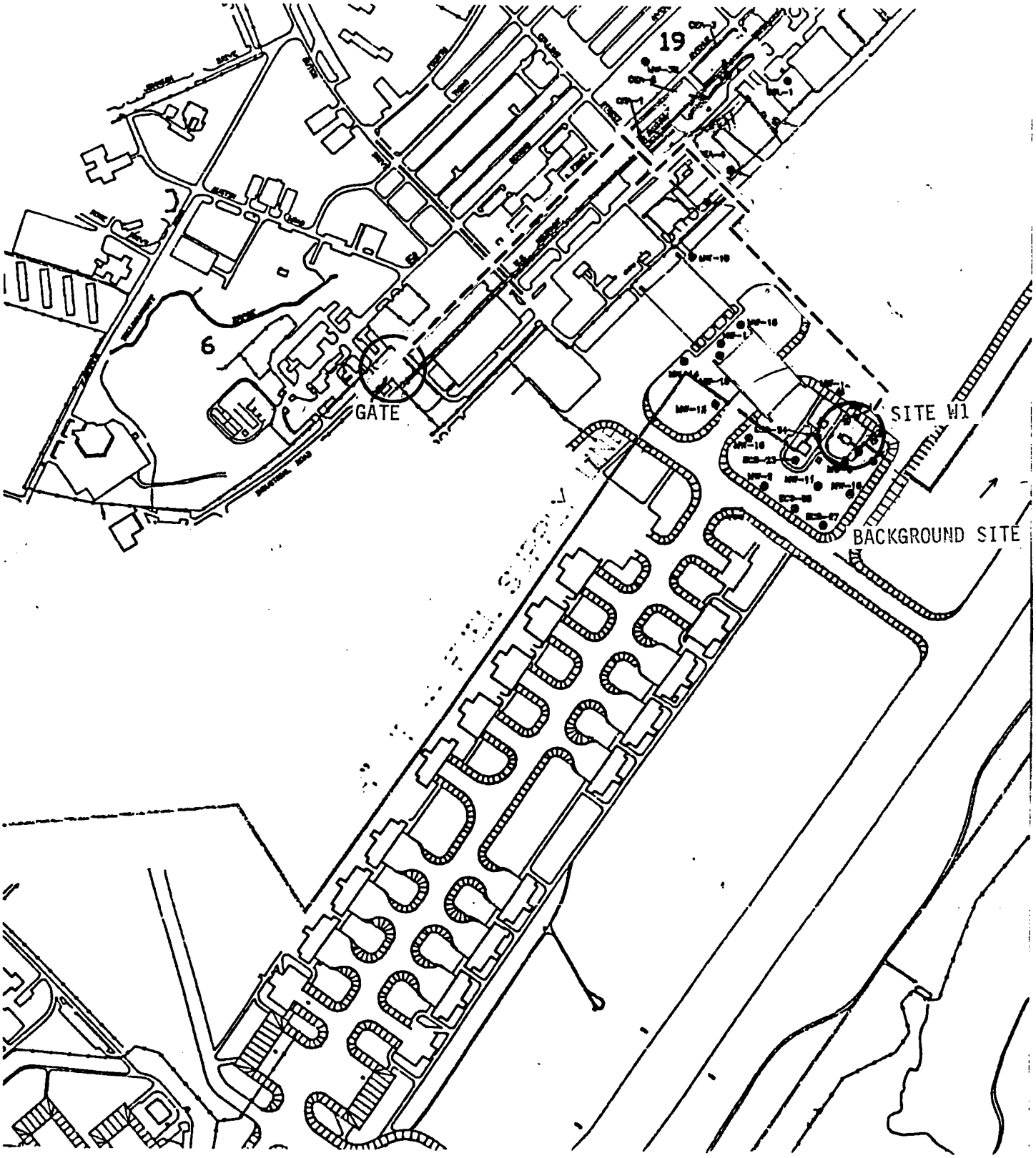

Figure 1. Schematic Diagram of Westover AFB

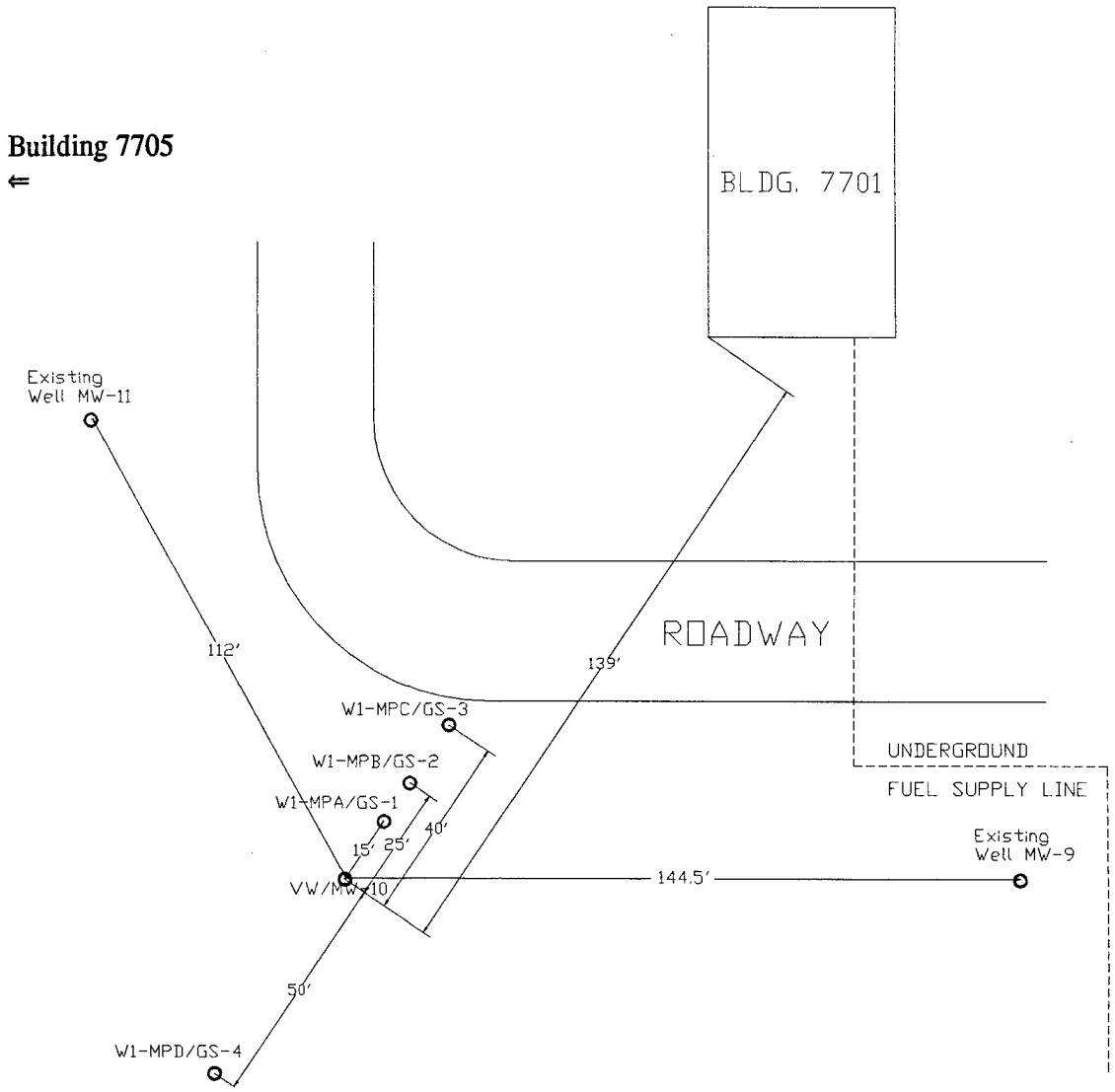

Figure 2. Schematic Diagram of Buildings 7701 and 7705 Site at Westover AFB (GS - Soil Gas Survey Point; MP - Monitoring Point)

2.2 Soil Gas Survey

A suitable site for the bioventing demonstration should have soil gas characteristics of high TPH, low oxygen, and high carbon dioxide concentrations. This composition of soil gas would indicate that oxygen-limiting conditions for microbial activity are present and that the introduction of air may enhance biodegradation of TPH.

On October 20, 1992, a limited soil gas survey was conducted at Buildings 7701 and 7705 Site. Soil gases were sampled by driving with a hammer drill sacrificial points which consisted of ¼-inch tubing with an aluminum, 4-inch screened area. Soil gas was withdrawn with a vacuum pump and analyzed for oxygen, carbon dioxide, and TPH.

Measurements of oxygen and carbon dioxide in the soil gas were made with a GasTech Model 32520X with oxygen and carbon dioxide ranges of 0 to 25%. The analyzer was calibrated daily against atmospheric oxygen, atmospheric carbon dioxide, a 10% oxygen calibration standard, and a 5% carbon dioxide calibration standard. TPH was measured with a GasTech Trace Techtor with TPH ranges from 0 to 100, 0 to 1,000, and 0 to 10,000 ppm. The GasTech Trace Techtor was calibrated daily against a 4,200-ppm hexane standard.

The soil gas probes were driven to depths ranging from 2.5 to 15 feet at several locations (Figure 2) at Buildings 7701 and 7705 Site. Table 1 provides the initial concentrations of oxygen, carbon dioxide, and TPH for the various locations at Buildings 7701 and 7705 Site. Oxygen concentrations varied from 0 to 4.2%, while TPH concentrations ranged from 7,200 ppm to greater than 40,000 ppm. The oxygen concentrations in the soil gas indicate that this site is oxygen-limited and will likely respond to bioventing.

2.3 Vent Well, Monitoring Point, and Thermocouple Installation

An existing monitoring well (MW-10) was used for the vent well at this site. The vent well was 30 feet deep and was screened from 12 to 30 feet.

On October 20, 1992, three three-level and one one-level monitoring points were installed. The monitoring points (MP) were labelled as follows: W1-MPA; W1-MPB; W1-MPC; and W1-MPD. The sacrificial points used for the soil gas survey were used as the monitoring points. The locations of the vent well and monitoring points are shown in Figure 2. A cross section of the vent well and monitoring points showing site lithology and construction detail is shown in Figure 3.

Table 1. Initial Soil Gas Composition at Buildings 7701 and 7705 Site

Soil Gas Survey (GS) Point	Depth (ft)	Oxygen (%)	Carbon Dioxide (%)	TPH (ppm)
GS-1	2.5	0.8	13.0	7,200
	5.0	0.8	13.5	7,200
	7.5	0.5	13.5	9,600
	10.0	0.5	13.5	12,400
	12.5	0.5	14.0	17,600
	14.0	4.2[1]	12.0	17,600
	15.0	ND	ND	ND
GS-2	2.5	0.2	13.0	15,000
	5.0	0.5	13.0	16,400
	7.5	0.5	13.5	18,000
	10.0	0.5	13.0	19,200
	12.5	0.0	13.5	36,800
GS-3	5.0	0.5	12.5	35,600
	10.0	1.5	12.0	37,600
	12.5	1.3	12.3	>40,000

ND No data collected. Groundwater was encountered at this depth.

[1] Pressure reading on sampling pump was high. Measured oxygen concentration may not be representative of actual soil gas oxygen concentrations. Actual oxygen concentration is likely to be lower.

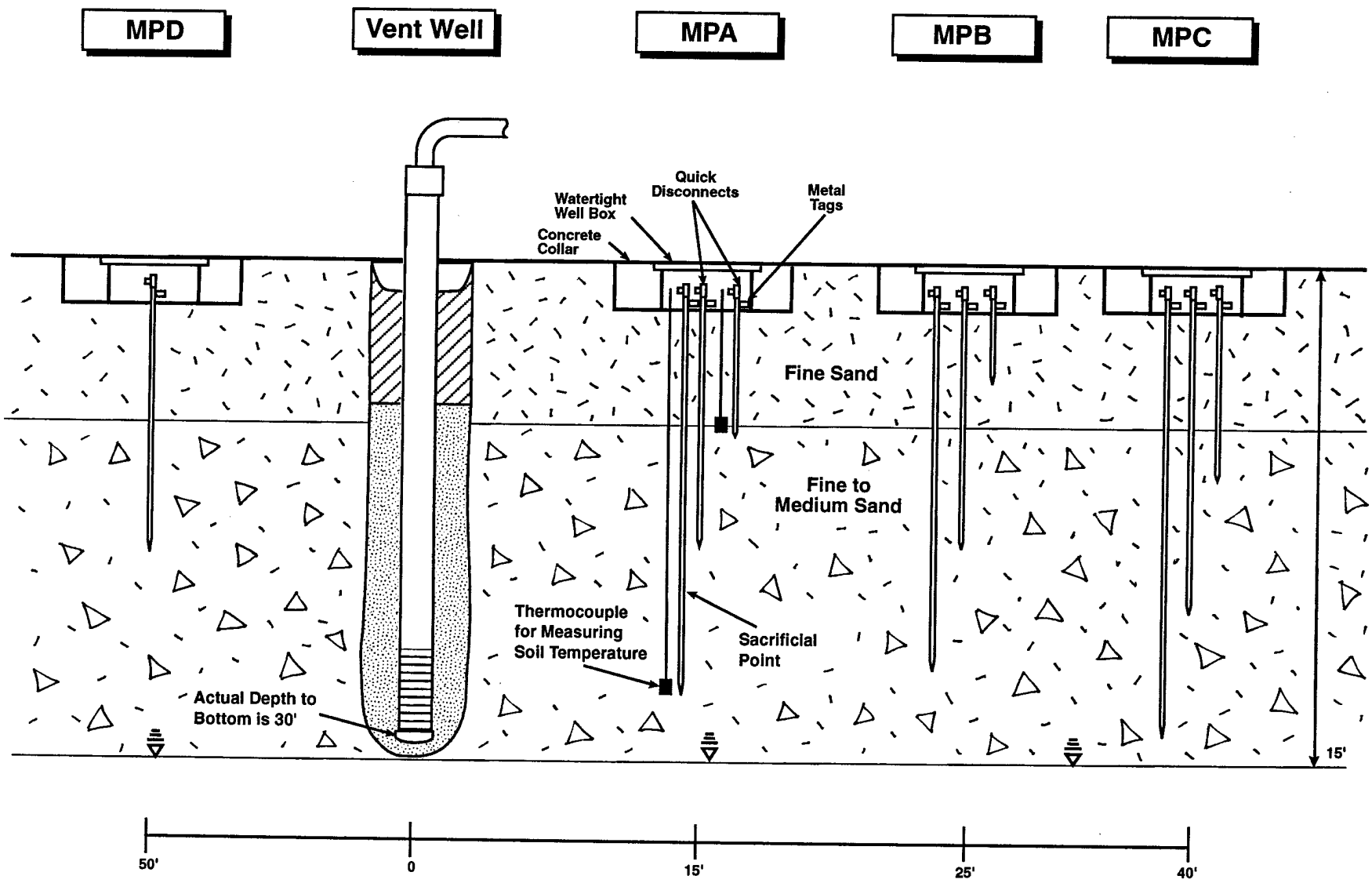

Figure 3. Cross Section of Vent Well and Monitoring Points at Buildings 7701 and 7705 Site Showing Site Lithology and Construction Detail (not to scale)

F/Kttel/W-1

Soil gas probes were sacrificial points which consisted of ¼-inch tubing with an aluminum, 4-inch screened area. No soil borings were created nor was any sand added. A small amount of wetted bentonite was added at the surface. The monitoring points were installed at depths as follows:

- Monitoring point W1-MPA was installed at the following three depths: 4.5, 8.5, and 13.5 feet.
- Monitoring point W1-MPB was installed at the following depths: 3.5, 8.5, and 12.5 feet.
- Monitoring point W1-MPC was installed at the following depths: 6.5, 10.5, and 14.5 feet.
- Monitoring point W1-MPD was installed at a depth of 9.0 feet.

A Type J thermocouple was installed with monitoring points W1-MPA-4.5′ and W1-MPA-13.5′.

2.4 Soil and Soil Gas Sampling and Analyses

Soil samples were collected near the vent well by hand auger. The soil samples were collected at depths of 9.0 to 9.5 feet and 12 to 12.5 feet, with two samples collected at each depth. The soil samples were labelled W1-EX-9 and W1-EX-9′-9.5′ for the 9.0 to 9.5 feet depth and W1-EX-12 and W1-EX-12′-12.5′ for the 12 to 12.5 feet depth. The samples were sent under chain of custody to Engineering-Science Inc., Berkeley Laboratory for analysis of benzene, toluene, ethylbenzene, and xylenes (BTEX); TPH; alkalinity; moisture content; pH; iron; total phosphate; total Kjeldahl nitrogen; and particle size analysis.

Soil vapor samples were not collected at this site during installation, but will be collected in spring 1993.

2.5 Soil Gas Permeability and Radius of Influence

A detailed description of the method for conducting a soil gas permeability test, including equations to compute k, the soil gas permeability, is given in the Test Plan and Technical Protocol (Hinchee et al., 1992).

Prior to air injection, the monitoring points were allowed to set up for 24 hours. Air was injected with a portable 1-horsepower (HP) explosion-proof positive displacement blower unit. After air injection was initiated, pressure readings were taken approximately every 1 to 2 minutes for the first hour, then approximately every 10 minutes for the following hour. Pressure readings also were collected from monitoring wells MW-9 and MW-11 (Figure 2). The Hyperventilate™ computer model was used to calculate the soil gas permeability.

2.6 In Situ Respiration Test

Immediately following the soil gas permeability test, air containing approximately 1% helium was injected into the soil for approximately 24 hours, beginning on October 27. Air was injected concurrently into the background monitoring well to measure the natural biodegradation of organic material in the soil. The setup for the in situ respiration test is described in the Test Plan and Technical Protocol (Hinchee et al., 1992). The pump used for air injection was a ½-HP diaphragm pump. Air and helium were injected through the following monitoring points at the depths indicated: W1-MPA-8.5′; W1-MPA-13.5′; W1-MPB-8.5′; and W1-MPB-12.5′. After the air/helium injection was turned off, the respiration gases were monitored periodically. The respiration test was terminated on October 30.

Helium concentrations were measured during the in situ respiration test to quantify helium leakage to or from the surface around the monitoring points. Helium loss over time is attributed to either diffusion or leakage. A rapid drop in helium concentration followed by a leveling is an indication of leakage. A gradual loss along with an apparent first-order curve is an indicator of diffusion. As a rough estimate, the diffusion of gas molecules is inversely proportional to the square root of the molecular weight of the gas. Based on molecular weights of 4 for helium and 32 for oxygen, helium gas diffuses about 2.8 times faster than oxygen, or the diffusion of oxygen is 0.35 times the rate of helium diffusion. As a general rule, we have found that if helium concentrations are at least 50 to 60% of the initial levels at test completion, measured oxygen uptake rates are representative. Greater helium loss indicates a problem, and oxygen utilization rates are not considered representative.

To compare data from one site to another, a stoichiometric relationship of the oxidation of the hydrocarbon was assumed. Hexane was used as the representative hydrocarbon for the organic contaminant. The stoichiometric relationship is given by:

$$C_6H_{14} + 9.5O_2 \rightarrow 6CO_2 + 7H_2O \quad (1)$$

Based on the utilization rates (% per day), the biodegradation rates in terms of milligrams as a hexane equivalent per kilograms of soil per day were computed using the equation below by assuming a soil porosity of 0.2 and a bulk density of 1,440 kg/m^3.

$$K_\beta = \frac{-K_o A D_o C}{100} \quad (2)$$

where: K_β = biodegradation rate (mg/kg/day)

K_o = oxygen utilization rate (percent per day)

A = volume of air/kg of soil, in this case 300/1,440 = 0.21

D_o = density of oxygen gas (mg/L) assumed to be 1,330 mg/L

C = mass ratio of hydrocarbon to oxygen required for mineralization, assumed to be 1:3.5 from the stoichiometric equation.

3.0 RESULTS AND DISCUSSION

3.1 Soil and Soil Gas Analyses

Results of the soil analyses for BTEX and TPH are presented in Table 2. The results of the soil chemistry analyses are summarized in Table 3. The analytical report for this site is presented in Appendix B. Although a hydrocarbon odor was detected at the time of collection of the soil samples, none of the BTEX compounds or TPH were detected in the soil samples. It seems unlikely that there is no soil contamination at the site, based upon the soil gas survey where relatively high concentrations of TPH were detected in soil gas. It may be necessary to collect an additional soil sample from this site, in case the lack of BTEX compounds or TPH in the soil samples was due to

Table 2. Results From Soil Analysis for BTEX and TPH at Buildings 7701 and 7705 Site

Sample Name	Benzene (mg/kg)	Toluene (mg/kg)	Ethylbenzene (mg/kg)	Total Xylenes (mg/kg)	TPH[1] (mg/kg)
W1-EX-9'-9.5'	<0.00060	<0.00070	<0.00050	<0.00090	<4.0
W1-EX-12'-12.5'	<0.00060	<0.00070	<0.00050	<0.00090	<4.0

[1] Referenced to a reference oil composed of a mixture of 2,2,4-trimethylpentane, *n*-hexadecane, and chlorobenzene.

Table 3. Results From Soil Chemistry Analysis at Buildings 7701 and 7705 Site

Parameter	Sample Name	
	W1-EX-9	W1-EX-12
Alkalinity (mg/kg $CaCO_3$)	<50	<50
Moisture (% by weight)	4.4	5.0
pH	6.2	6.0
Iron (mg/kg)	6,230	7,440
Total Phosphate (mg/kg)	530	630
Total Kjeldahl Nitrogen (mg/kg)	72	51
Particle Size Analysis (%)	Gravel: 1	Gravel: 0.50
	Sand: 80	Sand: 78
	Silt: 17.5	Silt: 20
	Clay: 1.5	Clay: 1.5

sampling or laboratory error. However, it also is possible that the samples were collected from an area of low contamination, although the majority of the site may be contaminated.

3.2 Soil Gas Permeability and Radius of Influence

The raw data for the soil gas permeability test at Buildings 7701 and 7705 Site are presented in Appendix C. Using the Hyperventilate™ computer model, soil gas permeabilities were calculated at each of the monitoring points. These data are presented in Table 4. The soil gas permeability values were relatively consistent except at one point where pressure changes could not be detected. Soil gas permeability values ranged 510,000 darcy up to 3.2×10^{10} darcy. The radius of influence is calculated by plotting the log of the pressure change at a specific monitoring point versus the distance from the vent well. The radius of influence would then be the distance where 1 inch of water pressure can be measured. Therefore, the radius of influence based on these specifications was approximately 6 feet (Figure 4).

3.3 In Situ Respiration Test

The results of the in situ respiration test for Buildings 7701 and 7705 Site are presented in Appendix D. Each figure in Appendix D illustrates the oxygen, carbon dioxide, and helium concentrations as a function of time. An example of typical oxygen utilization at this site is shown in Figure 5, where oxygen utilization and carbon dioxide production at monitoring point W1-MPB-12.5′ are illustrated. A summary of the oxygen utilization and carbon dioxide production rates and corresponding biodegradation rates is shown in Table 5. The biodegradation rates measured at this site were relatively high, with rates ranging from 4.4 mg/kg/day to 9.6 mg/kg/day based upon oxygen utilization, and from 2.6 mg/kg/day to 3.7 mg/kg/day based upon carbon dioxide production.

Loss of helium was insignificant at all monitoring points, indicating that the monitoring points were well sealed and that the oxygen depletion observed was a result of biodegradation.

Soil temperatures were measured during the in situ respiration test. Temperatures during the test ranged from 12.7°C to 13.3°C at monitoring point W1-MPA-4.5′ and from 15.3°C to 15.6°C at monitoring point W1-MPA-13.5′.

Table 4. Results of Hyperventilate™ Soil Gas Permeability Analysis at Buildings 7701 and 7705 Site

Monitoring Point[1]	Depth (ft)	Soil Gas Permeability (darcy)
W1-MPA	4.5	4.3×10^{9}
	8.5	3.2×10^{10}
	13.5	510,000
W1-MPB	3.5	1.6×10^{9}
	8.5	1.3×10^{9}
	12.5	2.6×10^{8}
W1-MPC	6.5	1.2×10^{8}
	10.5	4.2×10^{7}
	14.5	NR
W1-MPD	9.0	3.4×10^{8}

[1] Hyperventilate could not be calculated for data from MW-9 and MW-11, because measurements could not be taken until 30 minutes into the test.

NR No pressure readings were detected at this monitoring point.

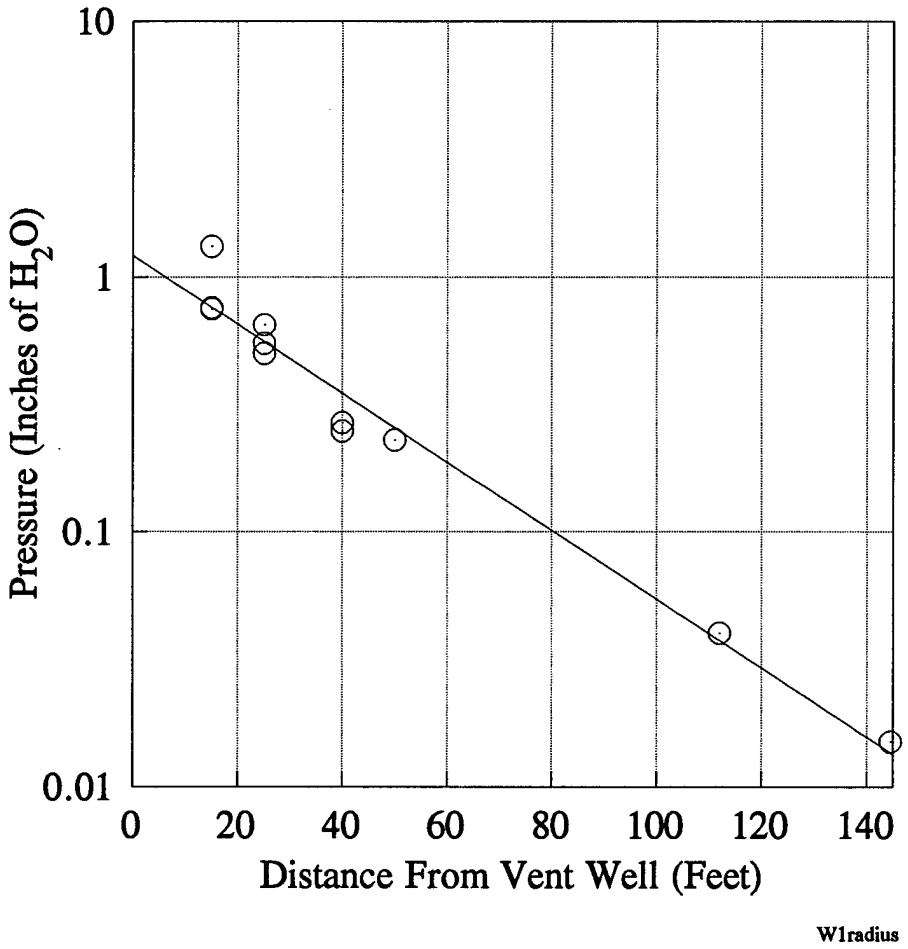

Figure 4. Radius of Influence at Buildings 7701 and 7705 Site

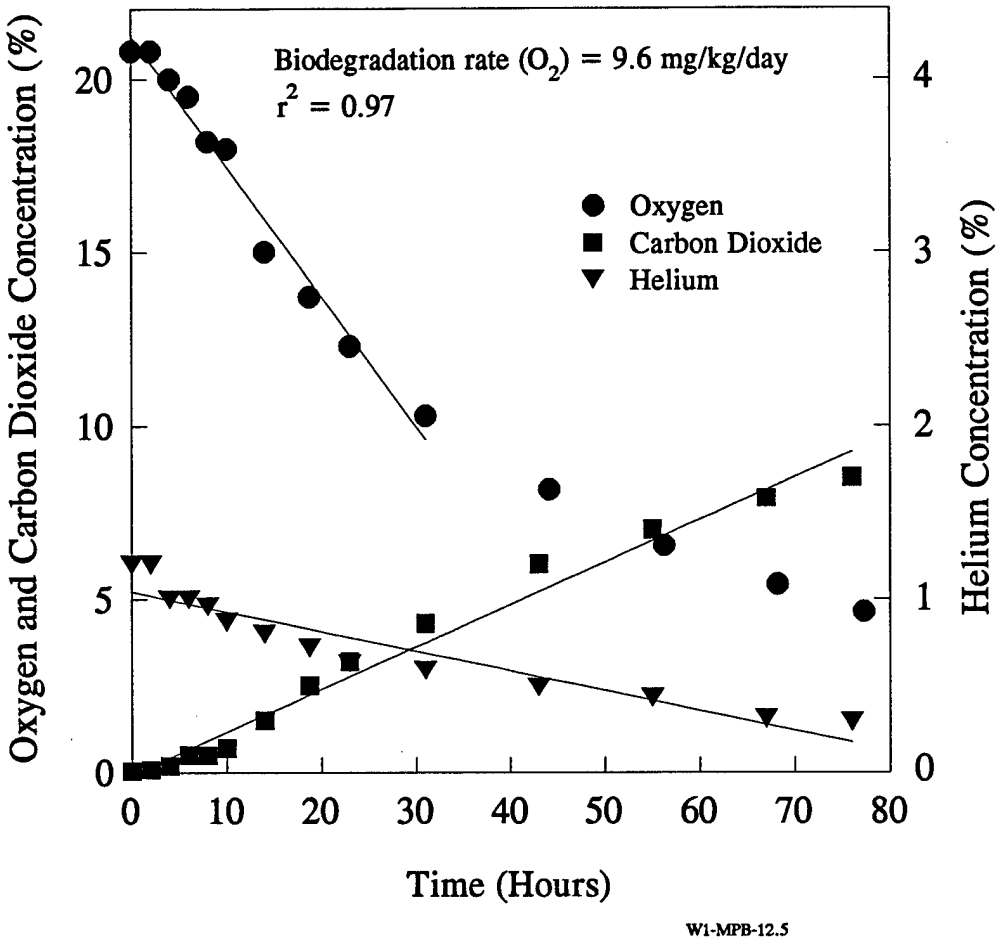

Figure 5. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point W1-MPB-12.5'

Table 5. Oxygen Utilization and Carbon Dioxide Production Rates During the In Situ Respiration Test at Buildings 7701 and 7705 Site

Monitoring Point	Oxygen Utilization Rate (%/hour)	Biodegradation Rate (mg/kg/day)	Carbon Dioxide Production Rate (%/hour)	Biodegradation Rate (mg/kg/day)
Background	0.012	0.23	0.010	0.22
W1-MPA-8.5′	0.23	4.4	0.15	3.2
W1-MPA-13.5′	0.25	4.8	0.12	2.6
W1-MPB-8.5′	0.34	6.5	0.17	3.7
W1-MPB-12.5′	0.50	9.6	0.15	3.2

3.4 Bioventing Demonstration

The decision was made to install a bioventing system at Buildings 7701 and 7705 Site. A 1-HP blower was installed at the site. Air injection has not been initiated at the site to date due to lack of electrical supply. The electricity is to be supplied by the base.

4.0 BACKGROUND AREA ACTIVITIES

An existing monitoring well (MW-36) was used as the background vent well. The existing vent well is located approximately 600 feet northeast from the vent well in the contaminated area (Figure 1) and is 20 feet deep and is screened from 10 feet to 20 feet. Groundwater was measured in the well at approximately 14.5 feet. Site lithology at this area was representative of that in the contaminated areas.

An in situ respiration test was conducted at the background area beginning on October 28 after 24 hours of air injection. The test was concluded on October 31. Very little decrease in oxygen concentration occurred during the course of the in situ respiration test (Figure 6).

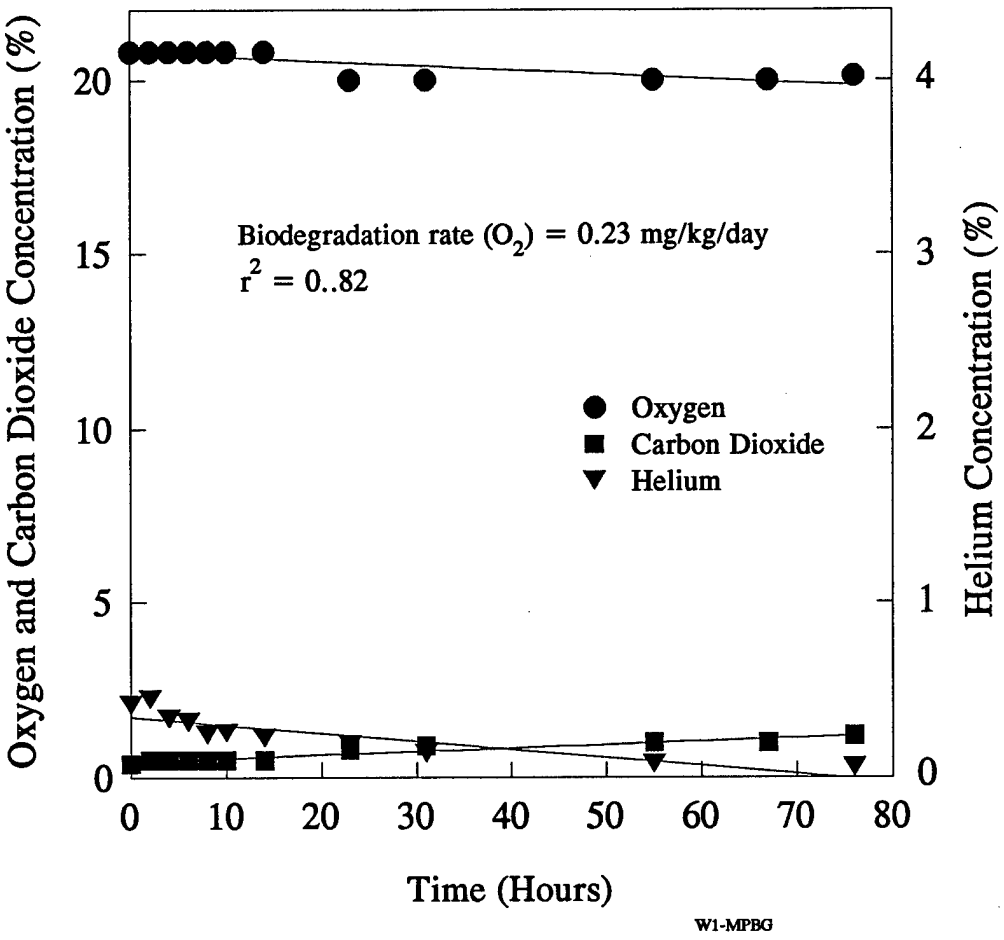

Figure 6. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at the Background Area

5.0 FUTURE WORK

Once the bioventing system is operating, base personnel will be required to perform a simple weekly system check to ensure that the blower is operating within its intended flowrate, pressure, and temperature range. An on-site briefing for base personnel who will be responsible for blower system checks will be conducted when the blowers are operational. The principle of operation will be explained, and a simple checklist and logbook will be provided for blower data. Base personnel will be asked to perform minor maintenance activities, such as replacing filters or gauges, or draining condensate from knockout chambers, but they will not be expected to perform complicated repairs or analyze gas samples. Replacement filters and gauges will be provided and shipped to the base, and serious problems, such as motor or blower failures, will be corrected by Battelle.

The progress of this system will be monitored by conducting semiannual respiration tests in the vent well and in each monitoring point and by regularly measuring the oxygen, carbon dioxide, and hydrocarbon concentrations in the extracted soil gas and comparing them to background levels. At least twice each year, the progress of the bioventing test will be reported to the base point-of-contact.

6.0 REFERENCE

Hinchee, R.E., S.K. Ong, R.N. Miller, D.C. Downey, and R. Frandt. 1992. *Test Plan and Technical Protocol for a Field Treatability Test for Bioventing* (Rev. 2), Report prepared by Battelle Columbus Operations, U.S. Air Force Center for Environmental Excellence, and Engineering Sciences, Inc. for the U.S. Air Force Center for Environmental Excellence, Brooks Air Force Base, Texas.

APPENDIX A

TEST PLAN FOR WESTOVER AFB, MASSACHUSETTS

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. . . Putting Technology To Work
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October 1, 1992

Capt. Catherine Vogel
Department of the Air Force
Building 1117
HQ AFESC/RDVW
Tyndall AFB, Florida 32403-6001

Dear Cathy:

SUBJECT: TEST PLAN FOR BIOVENTING INITIATIVE FIELD TEST AT WESTOVER AFB, MA.

This letter was prepared to accompany the report "Test Plan and Technical Protocol for a Field Treatability Test for Bioventing." The protocol document was developed as a generic test plan for the Air Force Bioventing Initiative Project in which Westover AFB is participating. This letter outlines site specific information to support the generic test plan.

The site anticipated for the bioventing test initiative is Building 7705 in the pumphouse apron area (see figure 1 for site map). This site is known to be contaminated with JP-4 jet fuel with soil TPH concentrations above 2000 ppm. The sources of contamination are the historic activities in the fuel hydrant area and a JP-4 fuel spill during Desert Shield activities.

The purpose of this project is to investigate the feasibility of using the bioventing technology to remediate petroleum contaminated soils at the above mentioned facility.

Site Description-

Building 7705 is located in the fuel pumphouse area. The test site for the Bioventing Initiative is located adjacent to Building 7705 and Building 7701. Site investigation activities in the area have indicated soils and groundwater are contaminated with JP-4 jet fuel (see Table 1). Groundwater is generally encountered at 12 to 15 ft below ground surface (bgs). Soils at the site consist of fine sand to approximately 5 ft bgs, fine to medium sand to 15 bgs, and fine sand with trace silt to 20 bgs. The approximate location of monitoring wells ECS-26 and ECS-24 have been drawn on Figure 1. ECS-26 is a likely candidate for use as the bioventing vent well. The soil boring log for ECS-26 is presented in Figure 3.

Project activities-

The following field activities are planned for the bioventing project at Westover AFB. Additional detail can be found in Section 5.0 of the generic test plan and technical protocol.

1- A small scale soil gas survey will be conducted to identify an appropriate location for installation of the bioventing system. Soil vapor from the candidate site must exhibit high petroleum hydrocarbon concentrations (10,000 ppm or greater), relatively low O_2 concentrations (0 % to 2.0 %), and relatively high CO_2 concentrations (depending on soil type, 2.0 % to 10.0 %). There are four monitoring wells in the area of Building 7705 (ECS-26, ECS-24, MW-11, and MW-12) that appear to be good candidates for use as bioventing wells. The soil gas survey will be concentrated around these wells.

   An uncontaminated background location will also be identified using soil gas survey techniques.

2- Once the installation site is located, one vent well and three 3-level soil gas monitoring points will be installed in the contaminated location and one vent well will be installed in the background area. The existing monitoring wells will be evaluated for use as the bioventing air injection well. If none of the existing wells are suitable for use as the bioventing well, a trailer mounted drill rig with solid or hollow stem auger will be used to bore down to just above the water table and install a 2-inch vent well. Three to four soil samples will be collected for chemical/physical analysis.

   Sacrificial drive points will be used for the permanent (three-level) soil gas monitoring points, if possible. Otherwise, the three-level points will be installed using the portable drill rig.

3- The air permeability test will be conducted in the contaminated test location.

4- Following the air permeability test, in situ respiration tests will be conducted in both the contaminated and the background test locations.

5- Depending on the results of the air permeability test and the in situ respiration test, a decision will be made whether or not to install a blower system in the contaminated area for the long term bioventing test. If the decision is made to install, the blower will be plumbed to the vent well and bioventing will be started (assuming power is available). Site personnel will be trained for blower operation prior to Battelle leaving the site.

Schedule-

Field activities at Westover AFB are planned to begin on October 19, 1992. Battelle will have 2 to 3 people on site for approximately 2 weeks.

Base Support-

Westover AFB needs to be able to provide the following:

- Digging permits and utility clearance for all sites need to be obtained prior to the initiation of the field work. Underground utilities should be clearly marked to reduce the chance of utility damage or personal injury during soil gas probe and well installation. Battelle will not be able to begin field operations without these clearances.

- Electrical power will need to be easily accessible from the project site. The air permeability test and in situ respiration test can be performed using a gasoline powered electric generator. The operation of the bioventing system will require a permanent 220/110 V power source. If power will not be available immediately after the test is completed the bioventing system will be installed for start-up at a later date.

- Regulatory approval, if any is required, will need to be obtained by the base prior to start-up of the bioventing system. The system will likely be configured for air injection so there will be no point source vapor emission from the system. The wells to be installed will not intersect the apparent water table and no groundwater will be pumped.

- Drums for containment of contaminated soil cuttings. The base will be responsible for disposal of any contaminated soils.

- Site specific safety information will be needed for incorporation into Battelle's Health and Safety Plan. This information includes: emergency phone numbers for ambulance, fire department, security, etc... .

- Base and site clearance will be required for Battelle's site employees. We will furnish the base POC with personal information for each person at least one week prior to starting field operations.

Thank you for your support for this bioremediation research project. If you have any questions please feel free to call me at (614) 424-6122.

Sincerely,

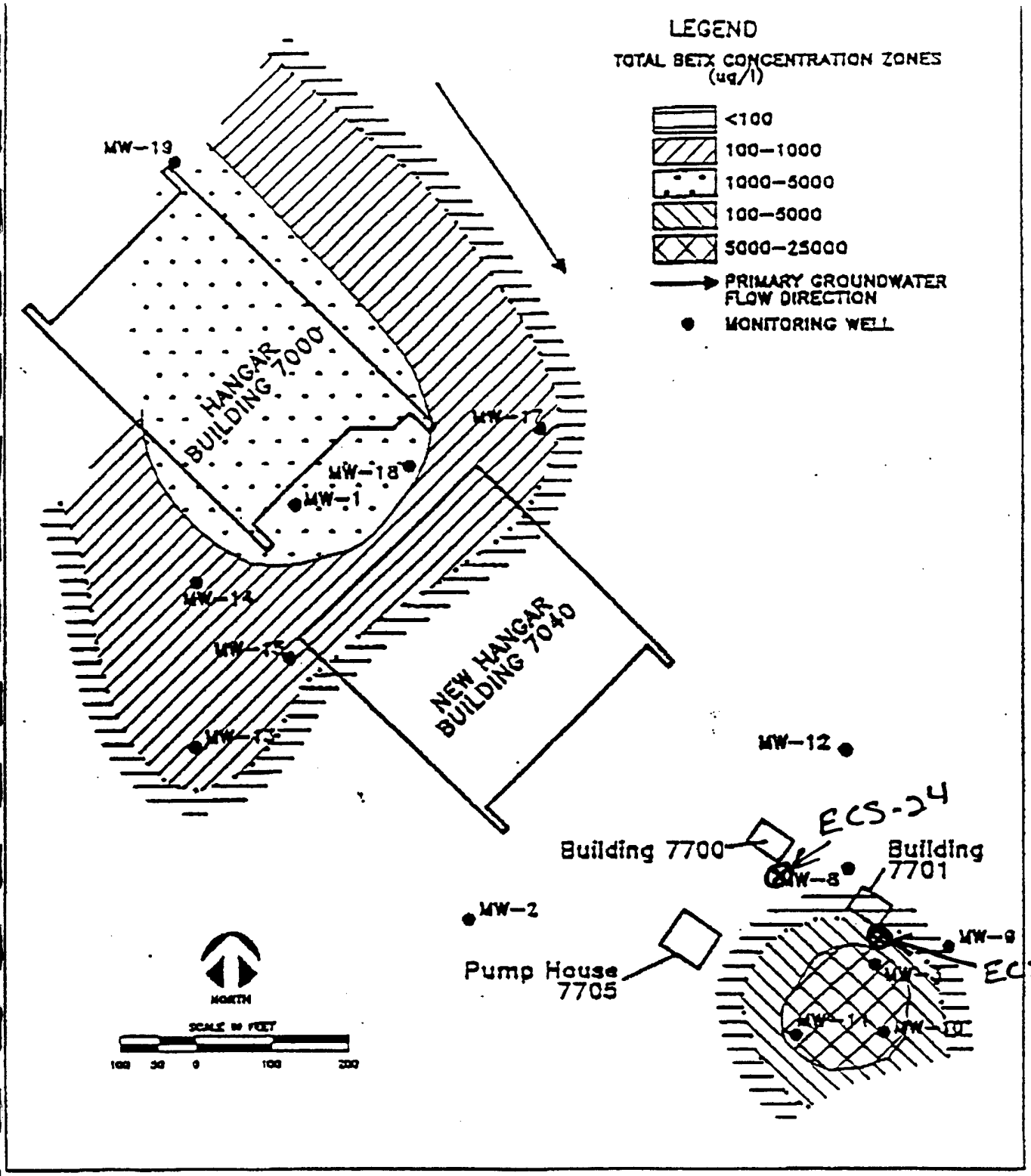
Jeffrey A. Kittel

JAK:sh
Enclosure
cc: Major Ross Miller (AFCEE)

TABLE 1. AVAILABLE GROUNDWATER ANALYTICAL RESULTS NEAR BUILDING 7705, WESTOVER AFB, MA.

Results	ECS-20	ECS-21	ECS-22	ECS-23	ECS-24	ECS-25	ECS-26	ECS-27	ECS-28	ECS-29	ECS-30	ECS-31	ECS-32	ECS-33	ECS-34	ECS-35
Benzene		200			180		1,000				300			840		540
Ethyl-benzene	380	2,100			1,300	1.6	670		11		76	820		820		
Isopropyl benzene	920	480	220	28	140	1.8	110					110		160		
Toluene	530	6,700			3,500		2,100				1,100	320		4,500		660
1,2,4-Trimethyl benzene	350	630	140	460	940	86	670				25	640		6,300		2,700
1,3,5-Trimethyl benzene	190	320	130	160	360		280					250		1,500		750
m,p-Xylenes	1,400	8,300		73	5,900		2,800		11		170	3,200		16,000		4,600
o-Xylene	400	1,600		120	2,200	2.8	1,000				52	1,100		6,600		4,200
Total BTEX	2,710	18,900		193	13,080	4.4	7,570		22		1,698	5,440		28,560		9,900
sec-Butyl benzene						2.8										
4-Isopropyl toluene						3.6										
n-Propyl benzene					110	1.0						90		160		
Naphthalene							120							670		190
Total VOC	4,170	20,330	490	831	14,630	99.6	8,760		22		1,723	6,530		37,510	65	15,840
MTBE														170	65	2,300

* All Results in micrograms per liter (ug/L).
* Empty Cell = Not Detected
* MTBE = Methyl Tertiary Butyl Ether
* Total VOC = Total Detected Volatile Organic Compound Concentration



WESTOVER AIR FORCE BASE, MA

HANGAR/APRON AREA

FIGURE 1. SITE MAP FOR WESTOVER AFB, MA.

[illegible] Environmental Consultants Services, Inc.

588 Silver Street, Agawam, Massachusetts 01001

SOIL BORING / MONITORING WELL LOG

SHEET 1 OF 1

LOCATION East of Pump House, near fueling station.

BORING COMPANY Kestrel Drilling & Remediation

JOB NUMBER 11407

PROJ. NAME Westover AFB

FOREMAN S. Burek

ADDRESS Chicopee, MA

ECS INSPECTOR M. Hanves

CLIENT Operational Contracting Office

GROUND WATER OBSERVATIONS			CASING		SAMPLER	CORE BAR
Date	Depth	Stabilization T	Type	H.S.A.	S.S.	
			Size I.D.	4 1/4"	1 3/8"	
			Hammer Wt.		140 lb.	
			Hammer Fall		30"	BIT
			Special Notes			

CASING ELEV.

SURFACE ELEV.

DATE STARTED 12/11/91

DATE COMPLETED 12/11/91

D	Sample Number	Sample Depths From - To	Penet. Recov.	Blows per 6" Penetration	Strata Changes	SOIL DESCRIPTION	Well As Built	Field Testing	Rem. (Note 1)
	S-1	0.0-2.0	24/13	4-5-7-7		3" Topsoil Loose, light brown medium SAND, trace medium Gravel, trace Silt.		42.0	4
5	S-2	5.0-7.0	24/14	2-2-2-4	FINE MEDIUM SAND	Loose, light brown fine-medium SAND, trace Silt.		6.2	
10	S-3	10.0-12.0	24/18	3-3-3-5		Loose, light brown/gray fine SAND, trace Silt.		13.3	
									2
15	S-4	15.0-17.0	24/16	2-2-3-3		Very loose, light gray fine SAND, little Silt.		190.0	
20	S-5	20.0-22.0	24/24	2-2-3-3		Very loose, gray fine SAND, trace Silt.		200.0	
					22' End of Boring				3

REMARKS

1. Field testing values represent total volatile organic compound vapor levels (referenced to a benzene standard) measured in the head space of sealed soil sample jars with an HNu Model PI - Photoionization Meter. Results reported in parts per million (ppm). Detection Limit = 0.2 ppm. BDL = Below Detection Limit.
2. Encountered groundwater at approximately 14'.
3. Installed 2" PVC monitoring well at 20' using 10' slotted screen and 10' solid riser. Sand pack to 7'; bentonite seal to 6'; natural fill to 0.5'; cement at surface with 2' stick-up lock.
4. Jet fuel odor throughout boring.

FIGURE 2. SOIL BORING LOG FOR MONITORING WELL ECS-26.

APPENDIX B

ANALYTICAL REPORT FOR BUILDINGS 7701 AND 7705 SITE

ES
ENGINEERING-SCIENCE, INC.

600 BANCROFT WAY
BERKELEY, CA 94710
Tel: (415) 548-7970 Fax: (415) 548-7635

Report Date: December 7, 1992

Work Order No.:4494

Client: Jeff Kittel
Battelle
505 Kings Ave.
Columbus, OH 43201

Date of Sample Receipt: 10/30/92

Your soil samples identified as:

W1-EX-9
W1-EX-12

were analyzed for pH, alkalinity, iron, moisture, total Kjeldahl nitrogen, total phosphorus and soil classification.

Finally your soil samples identified as:

W1-EX-9'-9.5'
W1-EX-12'-12.5'

were analyzed for BTEX by EPA Method 8020 and TRPH by EPA Method 418.1.

The analytical reports for the samples listed above are attached.

Berkeley,CA 94710

GC ANALYTICAL REPORT
Analytical Method
BTEX Aromatic Compounds

Work Order NO.:4494 % Moisture: 4.37

Client ID:W1-EX-9'-9.5' Matrix:SOIL

Laboratory ID:4494-1 Level:LOW

Date Collected: 10/22/92 Unit:UG/KG

Dilution Factor: 1 Date Analyzed:11/04/92
Date Confirmed:NA

Compound	Result	Reporting Limit
Benzene	ND	0.6
Ethyl Benzene	ND	0.5
Toluene	ND	0.7
Xylenes (total)	ND	0.9

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: AB

GROUP LEADER:

[illegible] ENGINEERING SCIENCE, INC.
Berkeley,CA 94710

GC ANALYTICAL REPORT
Analytical Method
BTEX Aromatic Compounds

Work Order NO.:4494 — % Moisture: 5.03

Client ID:W1-EX-12'-12.5' — Matrix:SOIL

Laboratory ID:4494-2 — Level:LOW

Date Collected: 10/22/92 — Unit:UG/KG

Dilution Factor: 1 — Date Analyzed:11/04/92
Date Confirmed:NA

Compound	Result	Reporting Limit
Benzene	ND	0.6
Ethyl Benzene	ND	0.5
Toluene	ND	0.7
Xylenes (total)	ND	0.9

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: [signature]

GROUP LEADER: [signature]

ES-Environmental Sciences, Inc.
Berkeley,CA 94710

GC ANALYTICAL REPORT
Analytical Method
BTEX Aromatic Compounds

Work Order NO.:4494 % Moisture:NA

Client ID:METHOD BLANK Matrix:SOIL

Laboratory ID:MSUG2921104B Level:LOW

Date Collected: NA Unit:UG/KG

Dilution Factor: 1 Date Analyzed:11/04/92
Date Confirmed:NA

Compound	Result	Reporting Limit
Benzene	ND	0.6
Ethyl Benzene	ND	0.5
Toluene	ND	0.7
Xylenes (total)	ND	0.9

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: AB

GROUP LEADER: [signature]

CA ENGINEERING SCIENCE, INC.
Berkeley, CA 94710

QUALITY CONTROL RESULTS SUMMARY
ANALYTICAL REPORT
BTEX AROMATIC COMPOUNDS

Work Order No.: 4494,4481

QC sample No.: 4481-4MS&MSD Date analyzed: 11/04/92

Matrix: SOIL Dilution factor: 1

COMPOUND 8010 analysis	SA UG/KG	SR UG/KG	MS UG/KG	MS %R	MSD UG/KG	MSD %R	RPD	QC LIMITS RPD	QC LIMITS %R
COMPOUND 8020 analysis	SA UG/KG	SR UG/KG	MS UG/KG	MS %R	MSD UG/KG	MSD %R	RPD	QC LIMITS RPD	QC LIMITS %R
Benzene	21	ND	18.2	87	20.2	96	10	29	39-150
Toluene	21	ND	19.8	94	20.8	99	5	28	46-148

MS = Spike sample
MSD = Spike sample duplicate
SR = Sample result
SA = Spike added
ND = Not Found At or Above Detection Limits

NC = Not calculated
NA = Not Applicable
** = Out of limits

RPD = 100 x (MS-MSD)/((MS+MSD)/2)

%R = 100 x ((MS or MSD) - SR)/SA

ANALYST: KB QC: JWB

ES-ENGINEERING SCIENCE,INC.
600 BANCROFT WAY
BERKELEY, CA 94710

GC ANALYTICAL REPORT
ANALYTICAL REPORT
BTEX AROMATIC COMPOUNDS

MATRIX: SOIL

DATE:11/04/92

LABORATORY NO.	CLIENT ID	a-a-a-TriFluoro Toluene
MSVG2921104B	METHOD BLANK	100
4494-1	W1-EX-9'-9.5'	94
4494-2	W1-EX-12'-12.5'	91
4481-2	KAFBA-SB10-SS3-4.5-5'	92
4481-3	KAFBA-SB10-SS4-5-5.5'	91
4481-4	KAFBA-SB10-SS5-6-8'	94
4481-4MS	KAFBA-SB10-SS5-6-8'MS	96
4481-4MSD	KAFBA-SB10-SS5-6-8'MSD	91
4481-5	KAFBA-SB11-SS2-5-5.5'	96
4481-6	KAFBA-SB12-SS2-5-5.5'	100

METHOD BLANK SUMMARY

WO # 4494,4481

LAB NAME : ENGINEERING-SCIENCE, INC. DATE ANALYZED : 11/04/92

LAB SAMPLE ID : MSVG2921104B DATE EXTRACTED : NA

MATRIX : SOIL INSTRUMENT ID : VGC-2

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE ANALYZED
MSVG2921104B	METHOD BLANK	11/04/92
4494-1	W1-EX-9'-9.5'	11/04/92
4494-2	W1-EX-12'-12.5'	11/04/92
4481-2	KAFBA-SB10-SS3-4.5-5'	11/04/92
4481-3	KAFBA-SB10-SS4-5-5.5'	11/04/92
4481-4	KAFBA-SB10-SS5-6-8'	11/04/92
4481-4MS	KAFBA-SB10-SS5-6-8'MS	11/04/92
4481-4MSD	KAFBA-SB10-SS5-6-8'MSD	11/04/92
4481-5	KAFBA-SB11-SS2-5-5.5'	11/04/92
4481-6	KAFBA-SB12-SS2-5-5.5'	11/04/92

ES-ENGINEERING SCIENCE, INC.
600 Bancroft Way
Berkeley,CA 94710

ORGANIC ANALYTICAL REPORT

Work Order NO.: 4494

Matrix: Soil

Parameter: TPH

Unit: mg/Kg

Analytical Method: 418.1

Date Extracted: 11/10/92

QC Batch NO.: S92QCB028TPH

Date Analyzed: 11/11/92

Sample ID:	Client ID:	Result	Reporting Limit	Percent Moisture
4494-01	W1-EX-9'-9.5'	ND	4	4.4
4494-02	W1-EX-12'-12.5'	ND	4	5.0
MSTPH921110	METHOD BLANK	ND	4	NA

NA_ Not Analyzed
ND_ Not Detected

ANALYST: _____

GROUP LEADER: _____

CASE NARRATIVE
WORK ORDER NO.4494
WET CHEMISTRY

Client ID's were abridged by the laboratory to facilitate computer entry of analytical data. The following should be used as a reference:

CLIENT ID	ABRIDGED ID
W1-EX-9'-9.5'	W1-EX-9
W1-EX-12'-12.5	W1-EX-12

The moisture analysis on samples W1-EX-9 (4494-01) and W1-EX-12 (4494-02) was conducted one day past analytical holding times as specified by the QAPjP.

ES-ENGINEERING-SCIENCE, INC.

600 Bancroft Way
Berkeley, CA 94710

INORGANICS ANALYTICAL REPORT

Client: ES-Denver
Project: AFCEE

Work Order: 4494
Matrix: Solid

Client's ID:	W1-EX-9	W1-EX-12
Sample Date:	10/22/92	10/22/92
% Moisture:		
Lab ID:	4494.01	4494.02

Parameter	Results		Method	Normal Report Limit	Units	Date Analyzed
Alkalinity	ND	ND	SM 403(M)	50	mg/Kg CaCO3	11/10/92
Moisture	4.4	5.0	ASTM D2216	.1	% by wt	11/06/92
pH	6.2	6.0	EPA 9045	NA	pH Units	11/04/92

Note: Samples for alkalinity analysis were extracted using 10mL water for each 1g sample. These water extracts were analyzed for alkalinity, and the results were calculated in the solid on a dry-weight basis.

NA- Not Applicable
ND- Not Detected

ANALYST: Don Gleaton

GROUP LEADER:

ES-ENGINEERING-SCIENCE, INC.
600 Bancroft Way
Berkeley, CA 94710

INORGANICS ANALYTICAL REPORT

Client: ES-Denver
Project: AFCEE
Work Order: 4494
Matrix: Solid

Client's ID: Prep Blank

Sample Date:
% Moisture:
Lab ID: Prep Blank

Parameter	Results	Method	Normal Report Limit	Units	Date Analyzed
Alkalinity	ND	SM 403(M)	50	mg/Kg CaCO3	11/10/92
Moisture	NA	ASTM D2216	.1	% by wt	11/06/92
pH	NA	EPA 9045	NA	pH Units	11/04/92

Note: Samples for alkalinity analysis were extracted using 10mL water for each 1g sample. These water extracts were analyzed for alkalinity, and the results were calculated in the solid on a dry-weight basis.

NA- Not Applicable
ND- Not Detected

ANALYST: Don Gleaton

GROUP LEADER:

ES-ENGINEERING-SCIENCE, INC.

600 Bancroft Way
Berkeley, CA 94710

INORGANICS QC SUMMARY - LAB CONTROL SAMPLE

Work Order: 4494

% Moisture: NA

Lab ID of LCS:
Alkalinity: 452.43 LCS

Matrix: Solid

Units: mg/Kg CaCO3

Parameter	Date Analyzed LCS	LCS Result	Conc Added	% Rec LCS	Advisory Limits -- % Rec -- Low	High
Alkalinity	11/10/92	22900.00	23650.00	97	80	120

ANALYST: Don Dleston Date 11/25/92 REVIEWER: MW Date 12/1/92

File:M1QCLCSW

CASE NARRATIVE
WORK ORDER NO. 4494
METALS - SOIL

Client ID's were abridged by the laboratory to facilitate computer entry of analytical data. The following should be used as a reference:

CLIENT ID	ABRIDGED ID
W1-EX-9'9.5'	W1EX09
W1-EX-12'-12.5'	W1EX12

ES-ENGINEERING-SCIENCE, INC.

600 Bancroft Way
Berkeley, CA 94710

INORGANIC QC SUMMARY - MS and MSD

Work Order: 4494

% Moisture: NA

Matrix: Solid

	Alkalinity	Moisture	pH
Lab ID Spk/Dup:	Blank Spk	4483.01	4466.01
QC Batch:	452.43	451.89	453.46

Units: mg/Kg CaCO3 (Alk)
% by wt. (Mois)
pH Units (pH)

Parameter	Date Analyzed MS/Dup	Unspiked Sample	MS/Sample	MSD/Dup	RPD	RPD QC Limit	-Conc Added- MS	MSD	Percent Recovered MS	MSD
Alkalinity	11/10/92	0.00	22900.00	22900.00	0	20	23650.00	23650.00	97	97
Moisture	11/06/92		13.53	13.47	0	20				
pH	11/04/92		5.22	5.19	1	20				

* or N = Outside QC Limit:

QC Limits for % Rec: 75 - 125

ANALYST: Don Gleaton Date 11/25/92 REVIEWER: MBB Date 12/1/92

File:M1QCMSWM

Engineering Science - Berkeley Laboratory
Inorganics Report

INORGANIC ANALYSES DATA SHEET

CLIENT SAMPLE ID: W1EX09

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_____

Lab Code: ESBL__ Case No.: 4494S SAS No.: _____ SDG No.: MPA-2_

Matrix (soil/water): SOIL_ Lab Sample ID: 4494.01___

Level (low/med): LOW__ Date Sampled : 10/22/92

% Solids: _95.6

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-89-6	Iron	6230			P

Comments:

FORM I - IN

3/90

Engineering Science - Berkeley Laboratory
Inorganics Report

INORGANIC ANALYSES DATA SHEET

CLIENT SAMPLE ID

W1EX12

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_____

Lab Code: ESBL__ Case No.: 4494S SAS No.: _____ SDG No.: MPA-2_

Matrix (soil/water): SOIL_ Lab Sample ID: 4494.02___

Level (low/med): LOW__ Date Sampled : 10/22/92

% Solids: _95.0

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-89-6	Iron	7440			P

Comments:

FORM I - IN

3/90

Engineering Science - Berkeley Laboratory
Inorganics Report

INORGANIC ANALYSES DATA SHEET

CLIENT SAMPLE ID

PBLANK

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_____

Lab Code: ESBL__ Case No.: 4494S SAS No.: _____ SDG No.: MPA-2_

Matrix (soil/water): SOIL_ Lab Sample ID: PBK 482.68

Level (low/med): LOW__ Date Sampled : 11/14/92

% Solids: 100.0

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-89-6	Iron	4.6	U		P

Comments:

FORM I - IN

3/90

Engineering Science - Berkeley Laboratory
Inorganic Report

ICP SERIAL DILUTION

EPA SAMPLE NO.

W1EX09L

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_____

Lab Code: ESBL__ Case No.: 4494S_ SAS No.: _____ SDG No.: MPA-2_

Matrix (soil/water): SOIL_ Level (low/med): LOW__

Concentration Units: ug/L

Analyte	Initial Sample Result (I)	C	Serial Dilution Result (S)	C	% Difference	Q	M
Iron	61936.83		67193.60		8.5		P

Engineering Science - Berkeley Laboratory

Method Detection Limits (Annually)

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_____

Lab Code: ESBL__ Case No.: 4494S_ SAS No.: _____ SDG No.: MPA-2_

ICP ID Number: TJA_61_____M Date: 08/31/92

Flame AA ID Number : _____ Matrix: SOIL_

Furnace AA ID Number : _____ (ug/L in 1.00g to 100ml digestate)

Analyte	Wave-length (nm)	Back-ground		MDL (ug/L)	M
Iron	271.44			46.0	P

Comments:

FORM X - IN ILMO2.

Engineering Science - Berkeley Laboratory
Inorganics Report

PREPARATION LOG

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_____

Lab Code: ESBL__ Case No.:_4494S_ SAS No.: _____ SDG No.:MPA-2_

Method: P_

EPA Sample No.	Preparation Date	Weight (gram)	Volume (mL)
LCSS	11/14/92	1.00	100
LCSSD	11/14/92	1.00	100
MPA-2	11/14/92	1.23	100
MPD-3	11/14/92	1.13	100
PBLANK	11/14/92	1.00	100
VMP1	11/14/92	1.28	100
VW-11	11/14/92	1.09	100
VW-3.5	11/14/92	1.12	100
VW1-11	11/14/92	1.19	100
W1EX09	11/14/92	1.04	100
W1EX12	11/14/92	1.07	100

Engineering Science - Berkeley Laboratory
Inorganics Report

ANALYSIS RUN LOG

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_____

Lab Code: ESBL__ Case No.: 4494S_ SAS No.: _____ SDG No.:MPA-2_

Instrument ID Number: TJA 61 M_ Method: P_

Start Date: 11/17/92 End Date: 11/17/92

EPA Sample No.	D/F	Time	% R	Analytes FE
STD1	1.00	0904		X
STD2	1.00	0909		X
STD3	1.00	0913		X
STD4	1.00	0918		X
ICV	1.00	0923		X
ICB	1.00	0927		X
ICSA	1.00	0932		X
ICSAB	1.00	0936		X
CRI	1.00	0941		
ZZZZZZ	1.00	0946		
PBLANK	1.00	0950		X
LCSS	1.00	0955		X
LCSSD	1.00	0959		X
W1EX09	1.00	1004		X
W1EX09L	1.00	1009		X
W1EX12	1.00	1013		X
CCV	1.00	1018		X
CCB	1.00	1022		X
VW-3.5	1.00	1027		X
MPD-3	1.00	1032		X
MPA-2	1.00	1036		X
VW-11	1.00	1041		X
VW1-11	1.00	1046		X
VMP1	1.00	1050		X
ICSA	1.00	1055		X
ICSAB	1.00	1059		X
CRI	1.00	1104		
CCV	1.00	1109		X
CCB	1.00	1113		X

SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.	Client Project ID:	W.O. #4494	Sampled:	Oct 22, 1992
600 Bancroft Way	Sample Descript:	Soil	Received:	Oct 30, 1992
Berkeley, CA 94710	Analysis for:	Total Phosphorous	Analyzed:	Nov 6, 1992
Attention: Tom Paulson	First Sample #:	210-4789	Reported:	Nov 17, 1992

LABORATORY ANALYSIS FOR: Total Phosphorous

Sample Number	Sample Description	Detection Limit mg/kg	Sample Result mg/kg
210-4789	W1-EX-9	10	530
210-4790	W1-EX-12	10	630
-	Method Blank	10	N.D.

THIS REPORT HAS BEEN APPROVED AND REVIEWED BY

ESBL PROJECT MANAGER 12/7/92 DATE

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL

Tod Granicher
Project Manager

Please Note:
Analysis results reported on a dry-weight basis.

SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.	Client Project ID:	W.O. #4494	Sampled:	Oct 22, 1992
600 Bancroft Way	Sample Descript:	Soil	Received:	Oct 30, 1992
Berkeley, CA 94710	Analysis for:	Total Kjeldahl Nitrogen	Analyzed:	Nov 9, 1992
Attention: Tom Paulson	First Sample #:	210-4789	Reported:	Nov 17, 1992

LABORATORY ANALYSIS FOR: Total Kjeldahl Nitrogen

Sample Number	Sample Description	Detection Limit mg/kg	Sample Result mg/kg
210-4789	W1-EX-9	20	72
210-4790	W1-EX-12	20	51
-	Method Blank	0.10	N.D.

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL

Tod Granicher
Project Manager

Please Note:
Analysis results reported on a dry-weight basis.

SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.	Client Project ID:	W.O. #4494	Sampled:	Oct 22, 1992
600 Bancroft Way	Sample Descript:	Soil	Received:	Oct 30, 1992
Berkeley, CA 94710	Analysis for:	Percent Solids	Analyzed:	Nov 11, 1992
Attention: Tom Paulson	First Sample #:	210-4789	Reported:	Nov 17, 1992

LABORATORY ANALYSIS FOR: Percent Solids

Sample Number	Sample Description	Detection Limit %	Sample Result %
210-4789	W1-EX-9	0.10	95
210-4790	W1-EX-12	0.10	94

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL

Tod Granicher
Project Manager

SEQUOIA ANALYTICAL

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(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.
600 Bancroft Way
Berkeley, CA 94710
Attention: Tom Paulson

Client Project ID: W.O. #4494

QC Sample Group: 210-4789, 90

Reported: Nov 17, 1992

QUALITY CONTROL DATA REPORT

ANALYTE	Total Kjeldahl Nitrogen	Total Phosphorous	Percent Solids	Total Phosphorous
Method:	EPA 351.4	EPA 365.3	EPA 160.3	EPA 365.3
Analyst:	G. Kern	K. Follett	Y. Arteaga	K. Follett
Reporting Units:	mg/kg	mg/kg	%	mg/kg
Date Analyzed:	Nov 9, 1992	Nov 6, 1992	Nov 11, 1992	Nov 6, 1992
QC Sample #:	211-0574	210-4790	2100-4790	Blank
Sample Conc.:	41	590	94	N.D.
Spike Conc. Added:	4000	100	N.A.	0.50
Conc. Matrix Spike:	3900	670	N.A.	0.40
Matrix Spike % Recovery:	96	80	N.A.	80
Conc. Matrix Spike Dup.:	3800	650	94	0.40
Matrix Spike Duplicate % Recovery:	94	60	N.A.	80
Relative % Difference:	2.6	30	0.0	0.0

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Tod Granicher
Project Manager

% Recovery: $\frac{\text{Conc. of M.S. - Conc. of Sample}}{\text{Spike Conc. Added}} \times 100$

Relative % Difference: $\frac{\text{Conc. of M.S. - Conc. of M.S.D.}}{\text{(Conc. of M.S. + Conc. of M.S.D.) / 2}} \times 100$

2104789.ENG <6>

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Engineering Science, Inc.	Client Project ID:	W.O. #4494	Sampled:	Oct 22, 1992
600 Bancroft Way	Sample Descript:	Soil, W1-EX-9	Received:	Oct 30, 1992
Berkeley, CA 94710	Method of Analysis:	ASTM D422-63	Analyzed:	Nov 10, 1992
Attention: Tom Paulson	Lab Number:	210-4789	Reported:	Nov 17, 1992

PARTICLE SIZE DISTRIBUTION BY SIEVE AND HYDROMETER

SIEVE TEST

(A) TOTAL WEIGHT OF SAMPLE:	244.93g
(B) WEIGHT RETAINED IN NO. 10 SIEVE:	7.79g
(C) % PASSING NO. 10 SIEVE:	96.82

SIEVE TEST FOR WEIGHT RETAINED IN NO. 10 SIEVE

SIEVE SIZE	WEIGHT RETAINED, g	% RETAINED	CUMULATIVE % RETAINED	CUMULATIVE % PASSING
1½ in.	0.0	0.0	0.0	100
3/8 in.	0.0	0.0	0.0	100
No. 4	1.55	0.63	0.63	99.37
No. 10	6.24	2.55	3.13	96.87
PAN	0.0			
TOTAL	7.79			

IDEAL PAN = 0.0
IDEAL TOTAL = (B)

HYDROMETER TEST

ELAPSED TIME (T)	TEMP. °C	HYDROMETER READING (H)	CORRECTED READING (R)	(L)	PARTICLE DIAM. (S)	% SUSPENDED (P)
2	19	9	5	15.5	0.038	4.2
5	19	8	4	15.6	0.024	3.4
10	19	7	3	15.8	0.017	2.5
15	19	7	3	15.8	0.014	2.5
25	19	7	3	15.8	0.011	2.5
40	19	7	3	15.8	0.0087	2.5
60	19	7	3	15.8	0.0071	2.5
90	19	6	2	16.0	0.0058	1.7
120	19	6	2	16.0	0.0050	1.7
1440	19	6	2	16.0	0.0015	1.7

WEIGHT OF SOIL USED IN HYDROMETER TEST (D):	115g
HYGROSCOPIC MOISTURE CORRECTION FACTOR (G):	0.995
SPECIFIC GRAVITY (ASSUMED):	2.65
DISPERSING AGENT CORRECTION FACTOR (E):	3
MENISCUS CORRECTION FACTOR (F):	1
TEMP./SPEC. GRAVITY DEPENDANT CONSTANT (K):	0.01382

FORMULAS:

$R = H - E - F$

$S = K [SQRT (L / T)]$

$P = (R / W) 100$

$W = (J \cdot 100) / C$

$J = D \cdot G$

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Tod Granicher
Project Manager

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(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.	Client Project ID:	W.O. #4494	Sampled:	Oct 22, 1992
600 Bancroft Way	Sample Descript:	Soil, W1-EX-12	Received:	Oct 30, 1992
Berkeley, CA 94710	Method of Analysis:	ASTM D422-63	Analyzed:	Nov 10, 1992
Attention: Tom Paulson	Lab Number:	210-4790	Reported:	Nov 17, 1992

PARTICLE SIZE DISTRIBUTION BY SIEVE AND HYDROMETER

SIEVE TEST

(A) TOTAL WEIGHT OF SAMPLE:	257.84g
(B) WEIGHT RETAINED IN NO. 10 SIEVE:	4.69g
(C) % PASSING NO. 10 SIEVE:	98.18

SIEVE TEST FOR WEIGHT RETAINED IN NO. 10 SIEVE

SIEVE SIZE	WEIGHT RETAINED, g	% RETAINED	CUMULATIVE % RETAINED	CUMULATIVE % PASSING
1½ in.	0.0	0.0	0.0	100
3/8 in.	0.0	0.0	0.0	100
No. 4	0.70	0.27	0.27	99.73
No. 10	3.99	1.55	1.82	98.18
PAN	0.0			
TOTAL	4.69			

IDEAL PAN = 0.0
IDEAL TOTAL = (B)

HYDROMETER TEST

ELAPSED TIME (T)	TEMP. °C	HYDROMETER READING (H)	CORRECTED READING (R)	(L)	PARTICLE DIAM. (S)	% SUSPENDED (P)
2	19	10	6	15.3	0.038	5.1
5	19	8	4	15.6	0.024	3.4
10	19	8	4	15.6	0.017	3.4
15	19	8	4	15.6	0.014	3.4
25	19	7	3	15.8	0.011	2.6
40	19	7	3	15.8	0.0087	2.6
60	19	6	2	16.0	0.0071	1.7
90	19	6	2	16.0	0.0058	1.7
120	19	6	2	16.0	0.0050	1.7
1440	19	6	2	16.0	0.0015	1.7

WEIGHT OF SOIL USED IN HYDROMETER TEST (D):	115g
HYGROSCOPIC MOISTURE CORRECTION FACTOR (G):	0.995
SPECIFIC GRAVITY (ASSUMED):	2.65
DISPERSING AGENT CORRECTION FACTOR (E):	3
MENISCUS CORRECTION FACTOR (F):	1
TEMP./SPEC. GRAVITY DEPENDANT CONSTANT (K):	0.01382

FORMULAS:
$R = H - E - F$
$S = K [SQRT (L / T)]$
$P = (R / W) 100$
$W = (J \cdot 100) / C$
$J = D \cdot G$

SEQUOIA ANALYTICAL

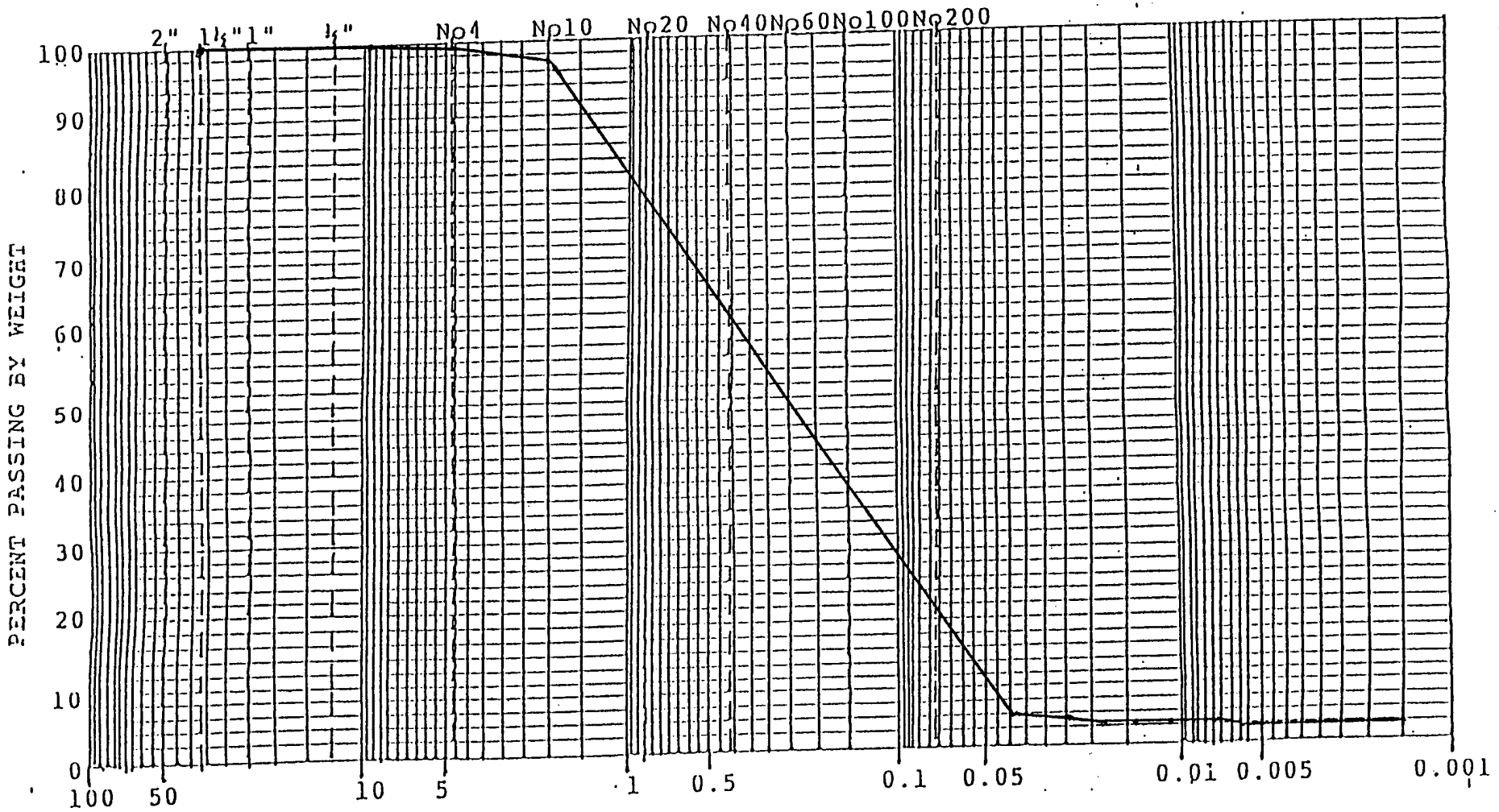
Tod Granicher
Project Manager

SAMPLE DESCRIPTION: Engineering Science, Inc.

LABORATORY NUMBER: 210-4789

GRAVEL	
SAND	80%
SILT	17.5%
CLAY	1.5%

U.S. STANDARD SIEVE SIZES

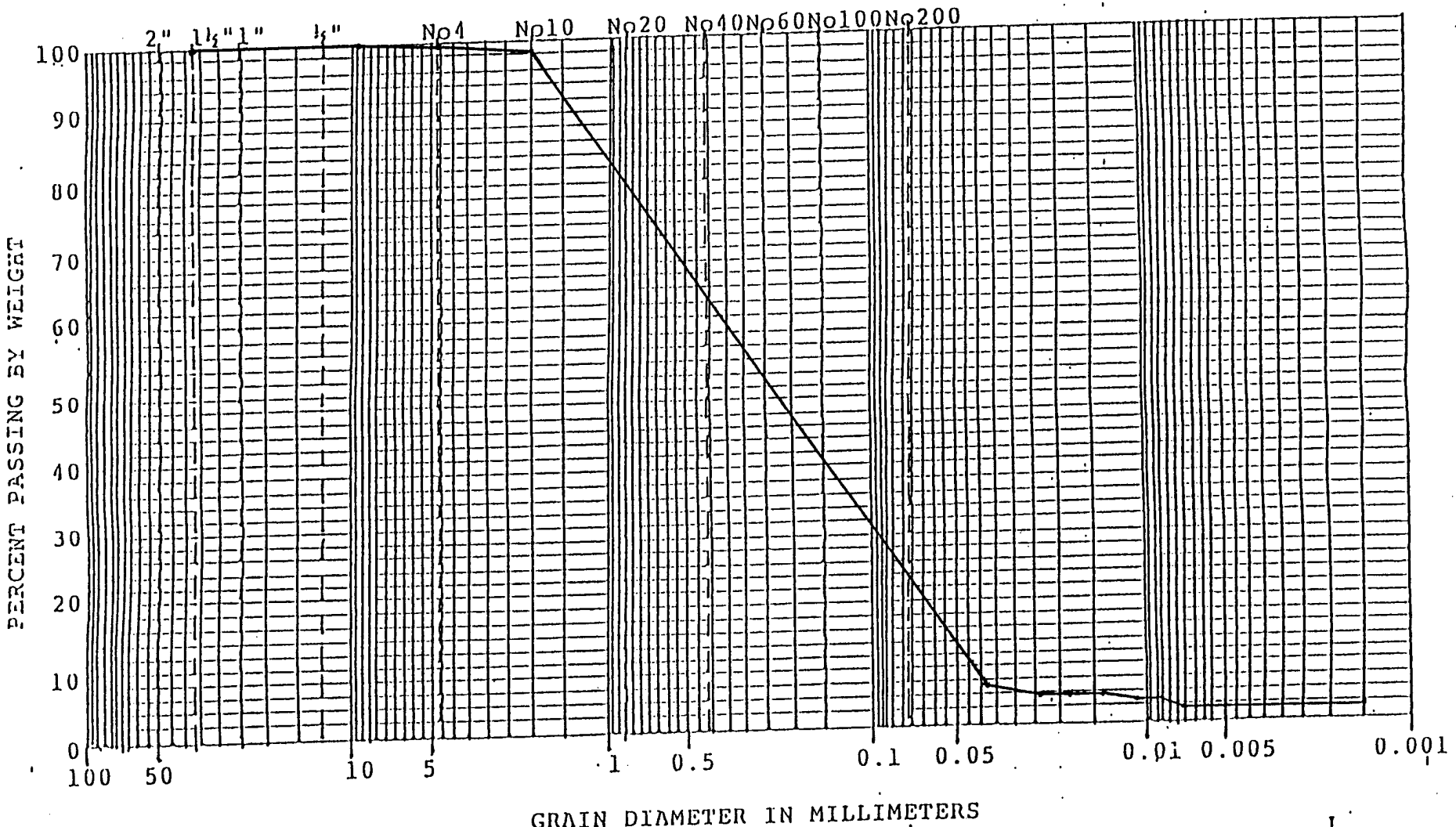


	COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES
OBBLES	GRAVEL		SAND			FINES	

SAMPLE DESCRIPTION: Engineering Science, Inc.

LABORATORY NUMBER: 210-4790

SAND	78%
SILT	20%
CLAY	1.5%



	COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES	
OBBLES	GRAVEL		SAND			FINES		

[redacted]-O[redacted] NU[redacted]R [redacted] / [redacted] OF [redacted]

ENGINEERING-SCIENCE

CHAIN OF CUSTODY RECORD

ES JOB NO.	PROJECT NAME/LOCATION	PRESERVATIVES REQUIRED	SHIP TO:
	W.O. 4494		Sequoia Analytical
FIELD CONTACT: Reidy Cleveland		ANALYSES REQUIRED	
SAMPLERS NAMES & SIGNATURES		TKN / TPO4 / STEVE ANALYSES OCAM (CLASS)	" Sub-Out "

DATE	TIME	FIELD SAMPLE IDENTIFIER	TKN	TPO4	STEVE ANALYSES OCAM (CLASS)		REMARKS
10/22/92	1200	W1-BX-S	X	X	X	4494-1C	2104789
↓	↓	" " -12	X	X	X	4494-2C	↓ 90

FIELD CUSTODY RELINQUISHED BY: Reidy Cleveland DATE: 10/30/92 TIME: 1410

SHIPPED VIA: AIRBILL # ON RECEIPT: CUSTODY SEALS? _____; TEMP: _____ °C

RECEIVED FOR LABORATORY BY: Patricia Wilk DATE: 10/30/92 TIME: 1410

RELINQUISHED BY Patricia Wilk 10/30/92 1610

10/30/92 1610

Battelle
Columbus Laboratories

Form No. 1

CHAIN OF CUSTODY RECORD

Proj. No.	Project Title
G 4468-0645	WESTOVER AFB CHICOPEE, MASS.

SAMPLERS: (Signature) Jon T Easley

DATE	TIME	SAMPLE I.D.	SAMPLE TYPE (√)													Container No.	Number of Containers	Remarks
			pH	Alkalinity	EC	Total Moisture	TKN	TPO4	Sieve Analysis	BTEX	TPH							
22 Oct	1200 hrs	W1-EX-9	✓	✓	✓	✓	✓	✓	✓								2	
"	"	W1-EX-12	✓	✓	✓	✓	✓	✓	✓								2	
"	"	W1-EX-9'-9.5'								✓	✓						1	SS
"	"	W1-EX-12'-12.5'								✓	✓						1	SS
																		Temp. SC

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Jon T Easley	10-28-92				
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks	
			10/30/92 0830	SEND RESULTS TO: c/o JEFF KITTEL BATTELLE MEM. INS.	

APPENDIX C

BUILDINGS 7701 AND 7705 SITE SOIL GAS PERMEABILITY DATA

Table C-1. Results of Soil Gas Permeability Test at Monitoring Point W1-MPA

Time (min)	Pressure ("H_2O) by Depth			Time (min)	Pressure ("H_2O) by Depth		
	4.5′	8.5′	13.5′		4.5′	8.5′	13.5′
0	0	0	0	26	0.75	0.75	1.29
1	0.65	0.68	1.25	29	0.74	0.75	1.27
4	0.75	0.76	1.30	35	0.76	0.76	1.32
5	0.75	0.75	1.31	40	0.76	0.76	1.31
6	0.74	0.75	1.33	45	0.75	0.76	1.30
7	0.74	0.75	1.33	50	0.75	0.76	1.30
8	0.75	0.76	1.32	55	0.74	0.75	1.27
9	0.74	0.75	1.30	60	0.74	0.75	1.29
10	0.76	0.77	1.34	65	0.74	0.75	1.29
12	0.74	0.75	1.29	75	0.74	0.75	1.30
14	0.75	0.75	1.30	85	0.74	0.75	1.30
16	0.74	0.75	1.29	95	0.74	0.76	1.30
18	0.74	0.75	1.29	115	0.75	0.76	1.29
20	0.75	0.76	1.30	120	0.74	0.75	1.29
23	0.75	0.75	1.29				

Table C-2. Results of Soil Gas Permeability Test at Monitoring Point W1-MPB

Time (min)	Pressure ("H_2O) by Depth			Time (min)	Pressure ("H_2O) by Depth		
	3.5′	8.5′	12.5′		3.5′	8.5′	12.5′
0	0	0	0	23	0.65	0.55	0.47
1	0.45	0.45	0.4	26	0.63	0.52	0.45
2	0.60	0.45	0.4	29	0.65	0.50	0.45
3	0.65	0.55	0.50	32	0.65	0.50	0.47
5	0.63	0.50	0.45	35	0.65	0.55	0.50
7	0.63	0.55	0.50	45	0.65	0.53	0.47
9	0.65	0.55	0.45	55	0.65	0.55	0.47
12	0.65	0.55	0.45	70	0.65	0.52	0.48
14	0.65	0.50	0.45	85	0.65	0.55	0.45
16	0.60	0.50	0.45	100	0.62	0.52	0.47
18	0.60	0.52	0.45	120	0.65	0.53	0.47
20	0.63	0.50	0.45				

Table C-3. Results of Soil Gas Permeability Test at Monitoring Point W1-MPC

Time (min)	Pressure ("H_2O) by Depth			Time (min)	Pressure ("H_2O) by Depth		
	6.5′	10.5′	14.5′		6.5′	10.5′	14.5′
0	0	0	0	26	0.23	0.24	0
1	0.17	0.20	0	29	0.23	0.23	0
3	0.20	0.20	0	32	0.25	0.25	0
6	0.20	0.20	0	35	0.25	0.245	0
8	0.20	0.20	0	45	0.25	0.25	0
12	0.25	0.20	0	55	0.26	0.27	0
14	0.20	0.20	0	70	0.24	0.24	0
16	0.20	0.20	0	85	0.22	0.22	0
18	0.20	0.20	0	100	0.23	0.2	0
20	0.23	0.24	0	120	0.235	0.24	0
23	0.23	0.25	0				

Table C-4. Results of Soil Gas Permeability Test at W1-MPD-9.0′ and Monitoring Wells MW09 and MW11

Time (min)	Pressure ("H_2O) at W1-MPD-9.0′	Time (min)	Pressure ("H_2O) at MW09	Time (min)	Pressure ("H_2O) at MW11
20	0.20	0	0	0	0
23	0.21	30	0.015	30	0.040
26	0.215	60	0.015	60	0.040
29	0.21	90	0.015	90	0.040
35	0.22	120	0.015	120	0.040
45	0.22				
55	0.235				
70	0.25				
85	0.215				
100	0.21				
120	0.23				

APPENDIX D

BUILDINGS 7701 AND 7705 SITE IN SITU RESPIRATION TEST DATA

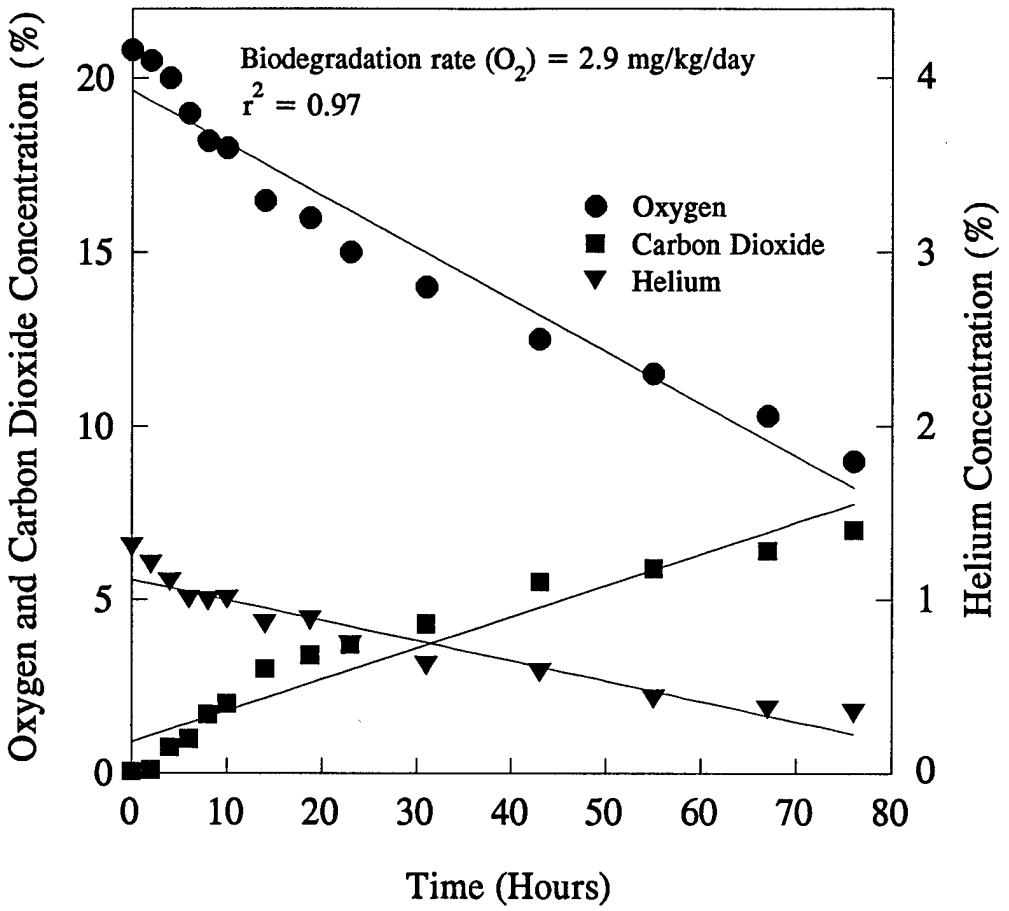


Figure D-1. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point W1-MPA-8.5'

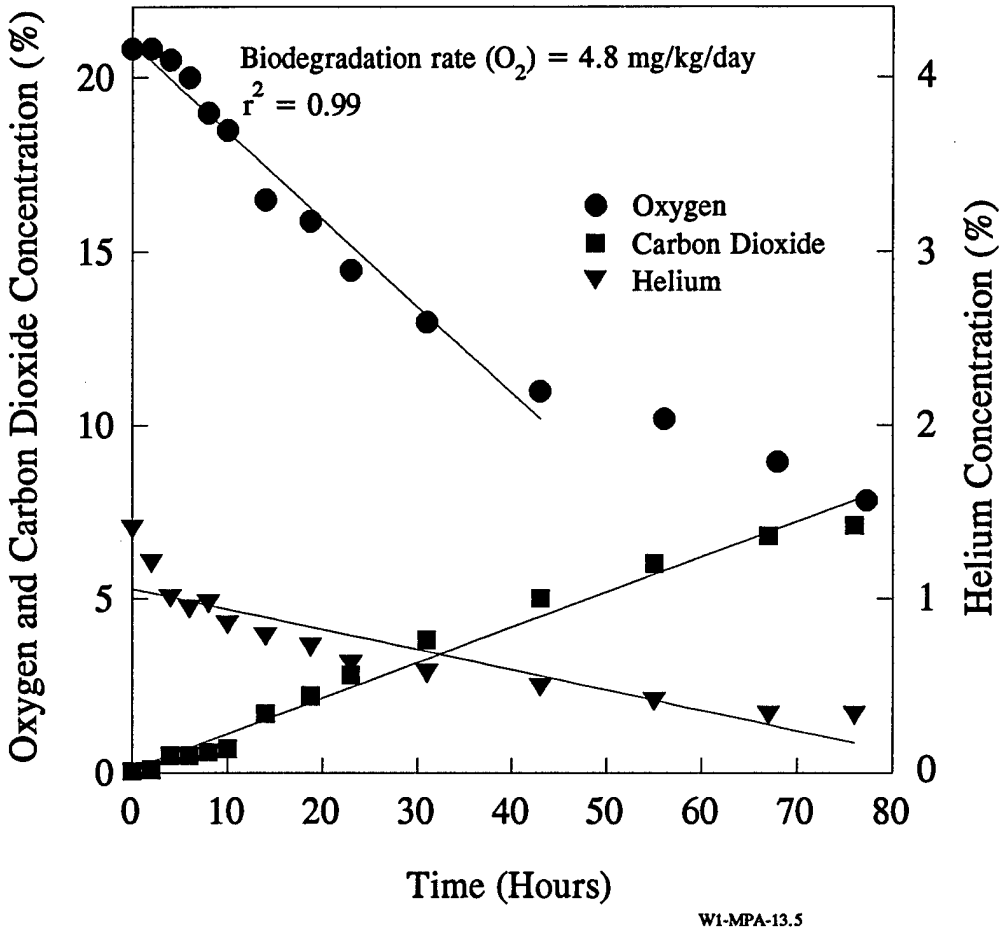


Figure D-2. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point W1-MPA-13.5′

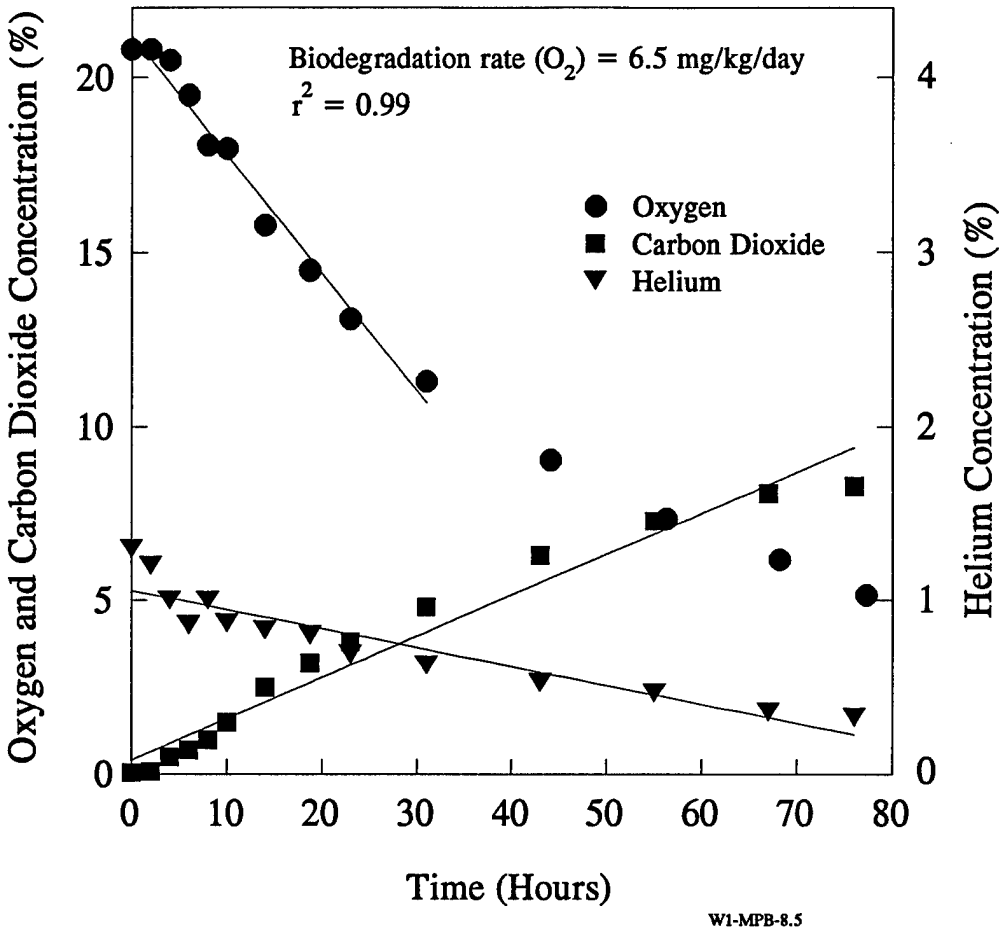


Figure D-3. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point W1-MPB-8.5'

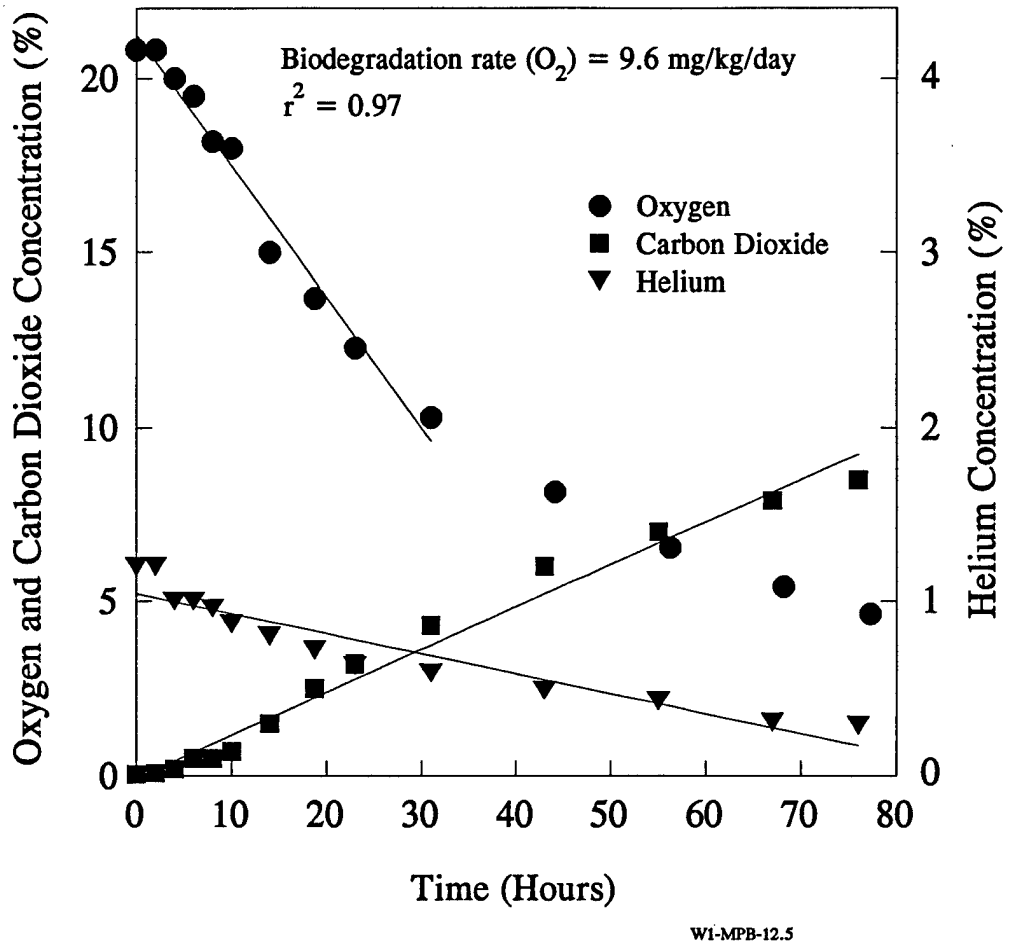


Figure D-4. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point W1-MPB-12.5'